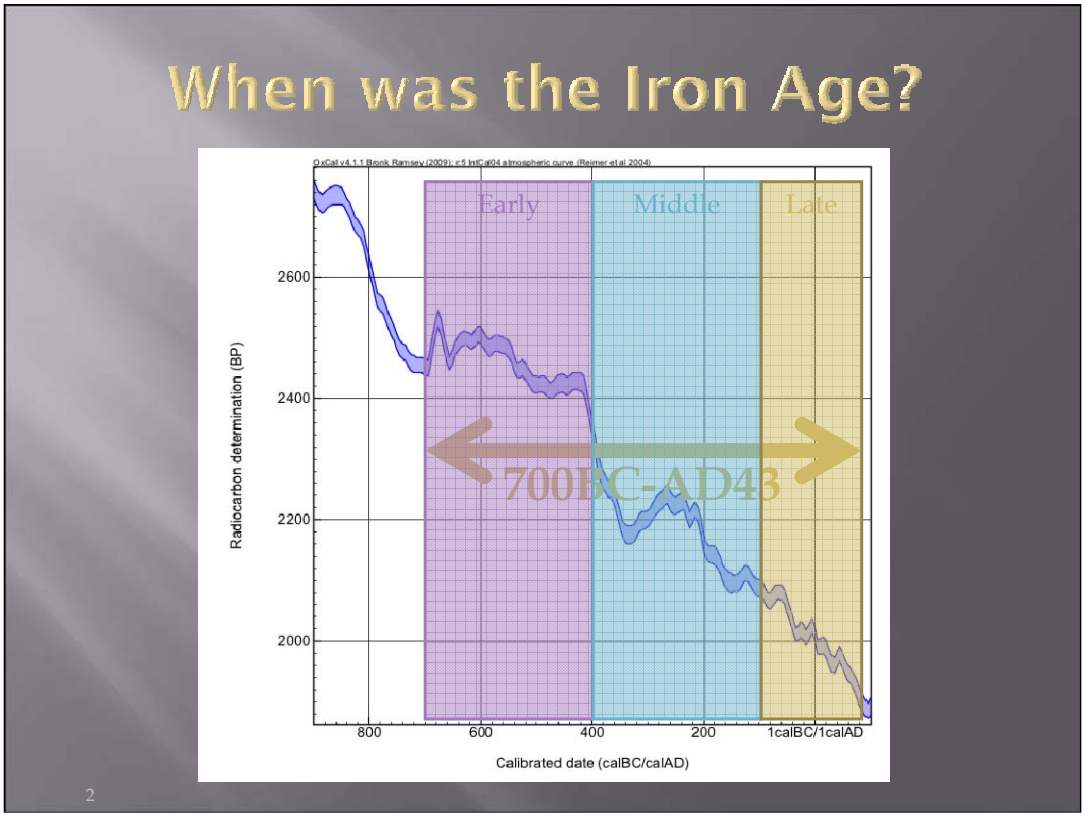
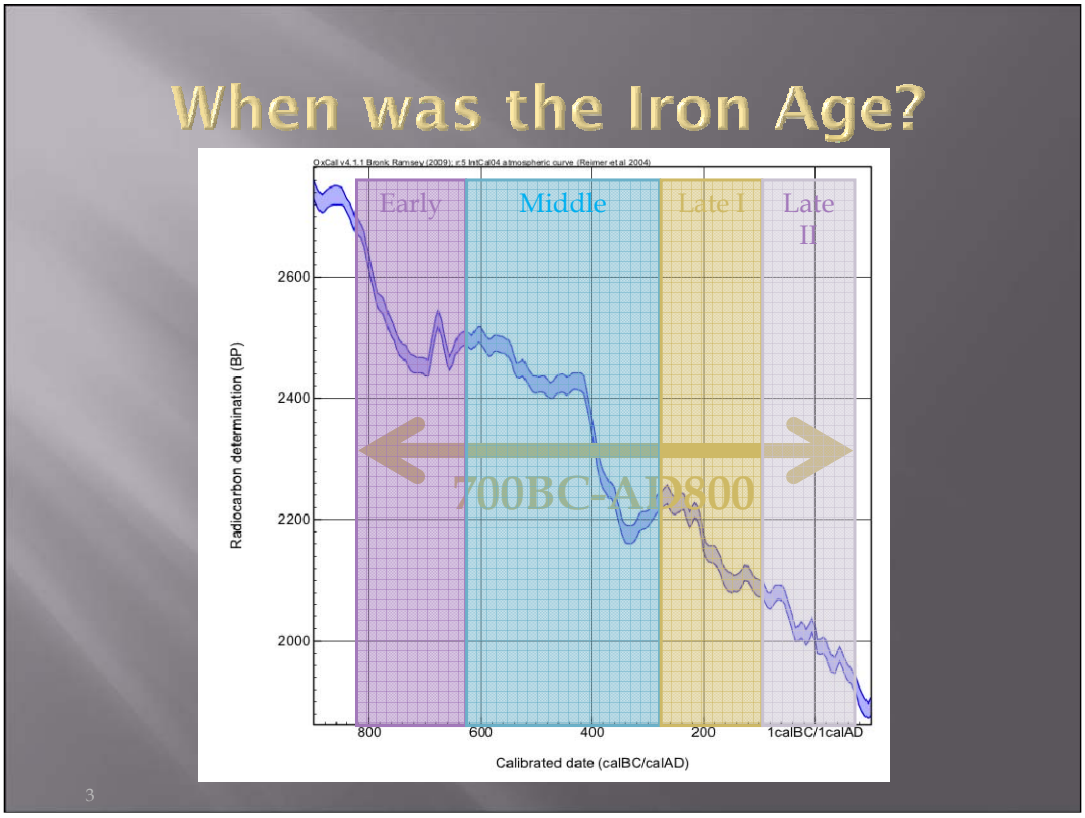
The question of dating the British Iron Age is slightly tangential to my research but it is the most obvious application of it and I believe it is an important issue to address. This is because all archaeological discussion on social or economic interpretations of past societies benefit from a reliable chronological framework, to enable the rates of changes observed to be put into context.

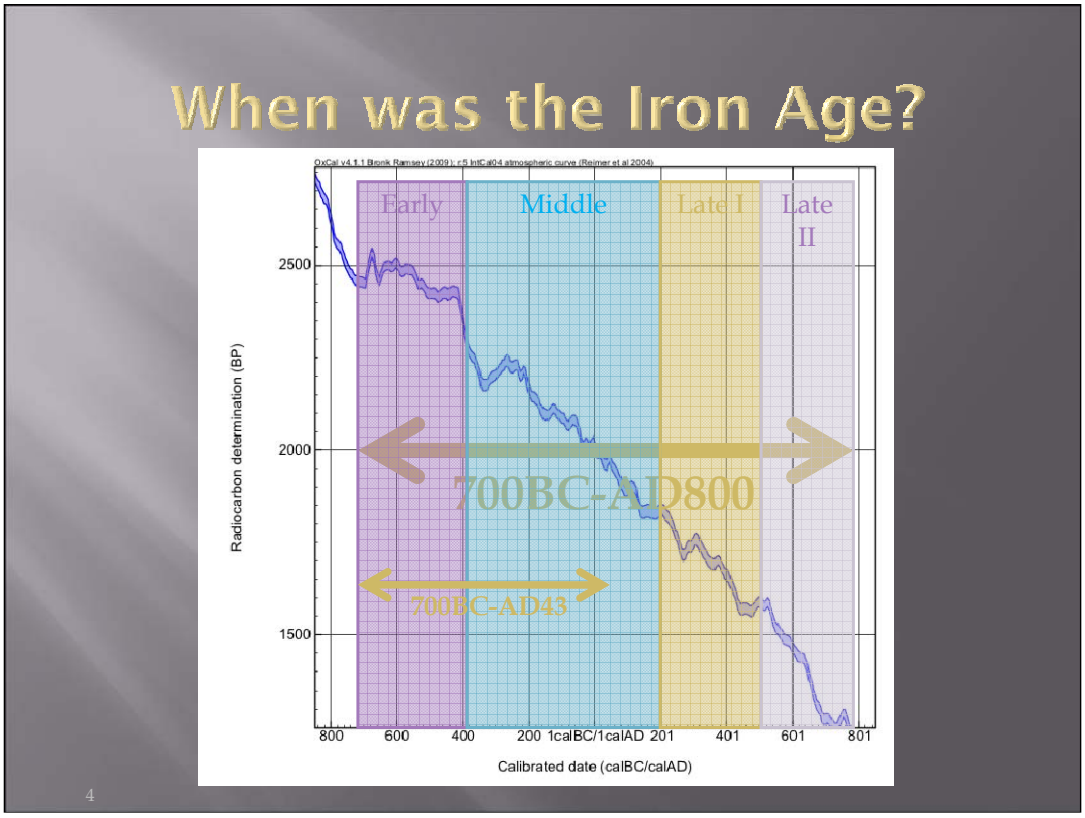


Traditionally the Iron Age is understood to have occurred between 700BC to AD43 and radiocarbon dating is considered to be unhelpful during this period due to “radiocarbon plateau”. However artefact typology has enabled archaeologists to develop sub periods to the IA

This shows that the plateau really only affects the early Iron Age period. Furthermore one of the wonderful things about the British IA is that there are many different Iron Ages. Regionality is an important and integral factor to the archaeology of the first millennium BC. These age ranges for example only apply to southern England, in Northern Britain the IA is considered to cover a much longer period.



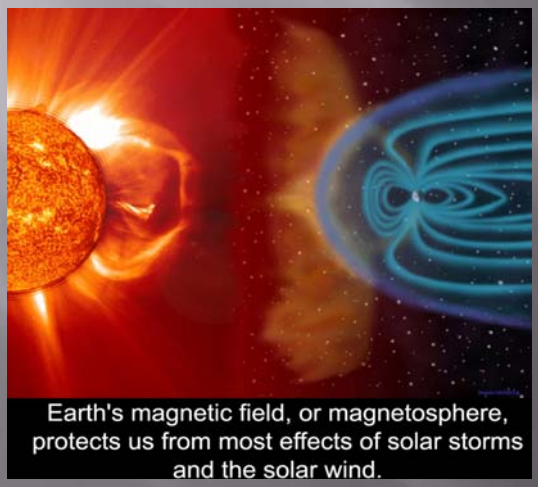
The Scottish Iron Age is at the opposite end of the spectrum of possible Iron Age date ranges and can also be divided into typologically distinct sub periods.

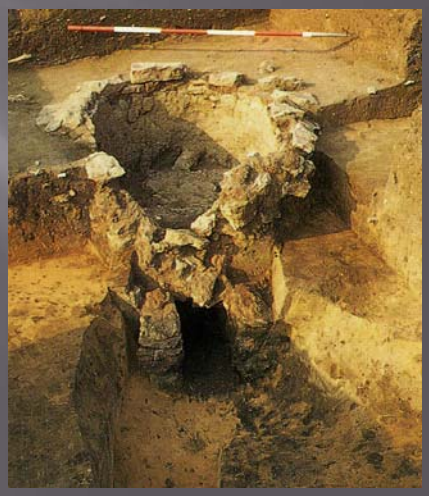


..and just to show how these two opposite ends of the spectrums compare.

Even so, radiocarbon and artefactual assemblages haven't been able to provide the chronological resolution to fully explore the changes occurring in this period. There is another, currently under exploited dating method that may be able to address this problem.

Archaeomagnetism is the study of the geomagnetic field in the past





Images: ©NASA (left); May 1996, plate 36 (right)

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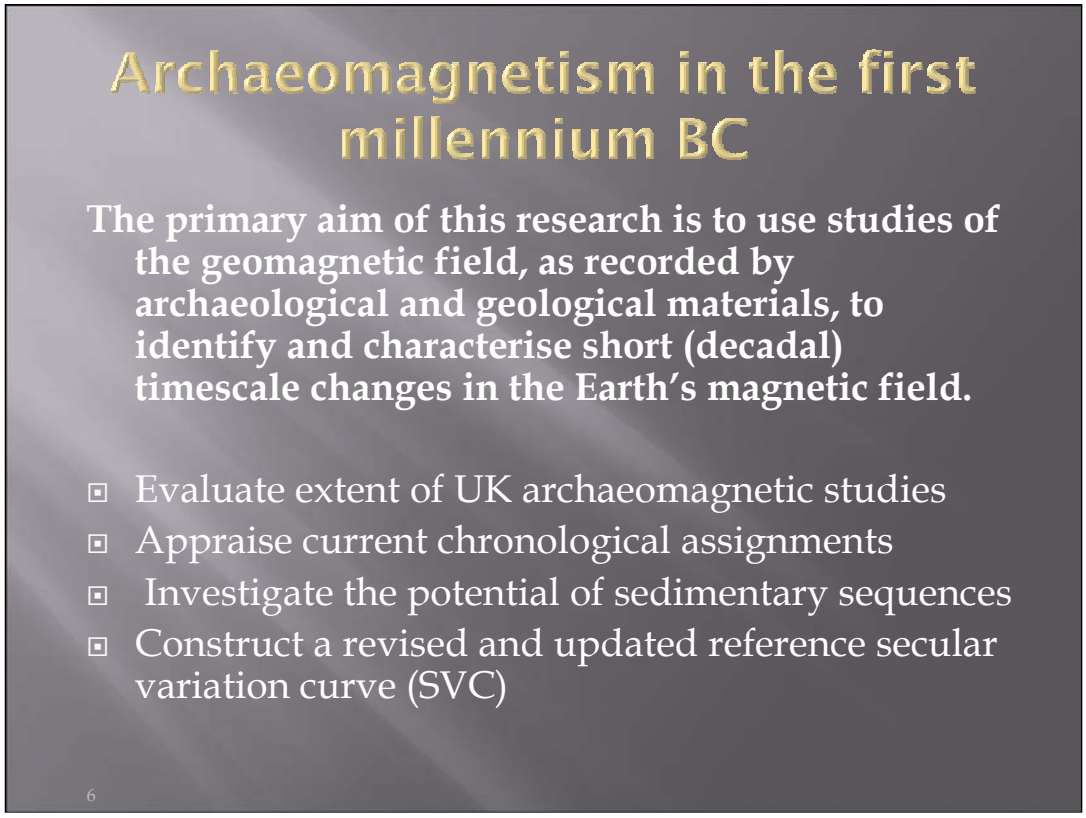
This is archaeomagnetic dating, which is the study of the geomagnetic field in the past. It is based on two physical phenomena: that the earth has a geomagnetic field which changes over time and that under certain conditions naturally occurring minerals can record the ambient geomagnetic field. One of these conditions is the action of heat on clay, so is ideally suited to directly date anthropogenic activity via pyrotechnological process. Whether that is hearths, kilns, ovens, furnaces or hypocausts.

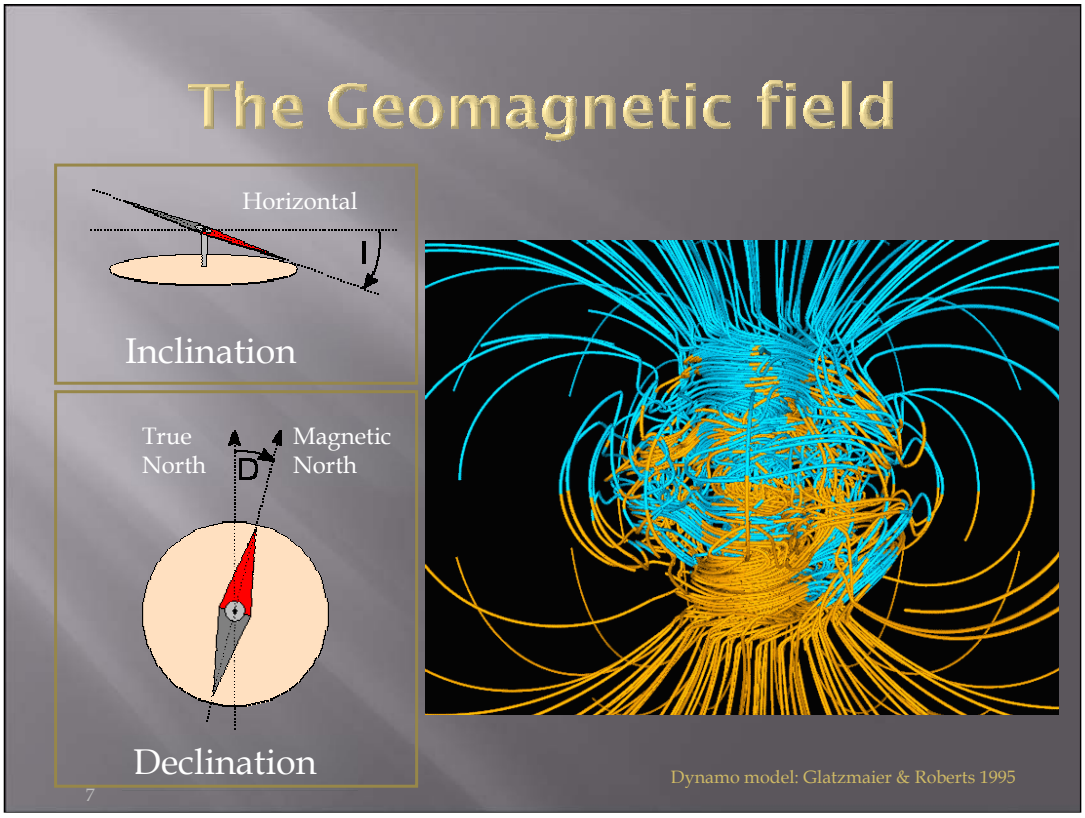


So the primary aim of my research is to use studies of the geomagnetic field as recorded by archaeological and geological materials to identify and characterise short (decadal) timescale changes in the Earth's magnetic field.

Essentially I am attempting to construct a calibration curve for AM dating, this is generally referred to as a secular variation curve or SVC.

Although I am not the only research working on identifying past changes in the geomagnetic field my research is unique in that I am deconstructing the current curve and reassessing the database before addressing the problem of how best to produce and present a calibration curve. The database is a collection of individual magnetic directions that previous workers have had to determine the point in time they relate to and generally these workers have not been archaeologists so perhaps have not fully appreciated the nature of the material they have been working with.

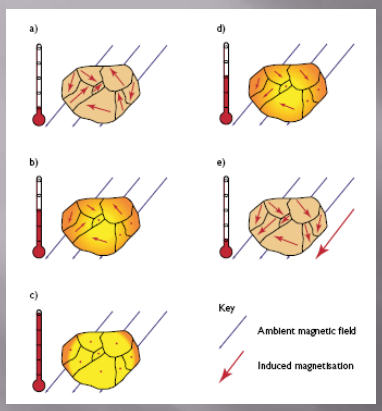
With regards to geological materials, lake sediments also provide a record of the changes in the ambient geomagnetic field over time but opinion is divided amongst palaeomagnetists on the accuracy of this dataset and whether it should be included in a SVC.



The geomagnetic field can be understood as a dipole, like a bar magnet, but magnetic N and geographical N are not the same. Furthermore magnetic N is not static and changes from year to year. Although not fully understood the presence of the geomagnetic field is explained by dynamo theories, where fluid motion of the Earth's liquid core creates a self enforcing field. However the dipole only describes 80% of the observed behaviour, the remaining 20% is localised effects. These non-dipole components mean that SVC can only be regional records and cover an area of about 500km

The magnetic field is described by vectors, the two components are declination and inclination together these describe the direction of magnetic N and are the data I have been working with. Vectors also have a strength or in this case a magnetic intensity but this parameter has proven more technically challenging to recover from archaeological and geological material. Magnetic intensity also varies temporally and spatially but I have not included this component.

Thermo Remanent Magnetisation



Under certain conditions iron oxides naturally present within clays can record and archive the contemporary geomagnetic field

Images: © Paul Linford (left); © Martin Carruthers (right)

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For archaeological material the main mechanism by which the contemporary geomagnetic direction was captured is TRM.

On heating there is competition between the thermal disordering forces and the magnetic ordering forces and above 550°C the magnetic order is broken down. As the substance cools the magnetic ordering is restored but is influenced by the ambient field providing the material with a net magnetic direction which is stable over archaeological timescales.

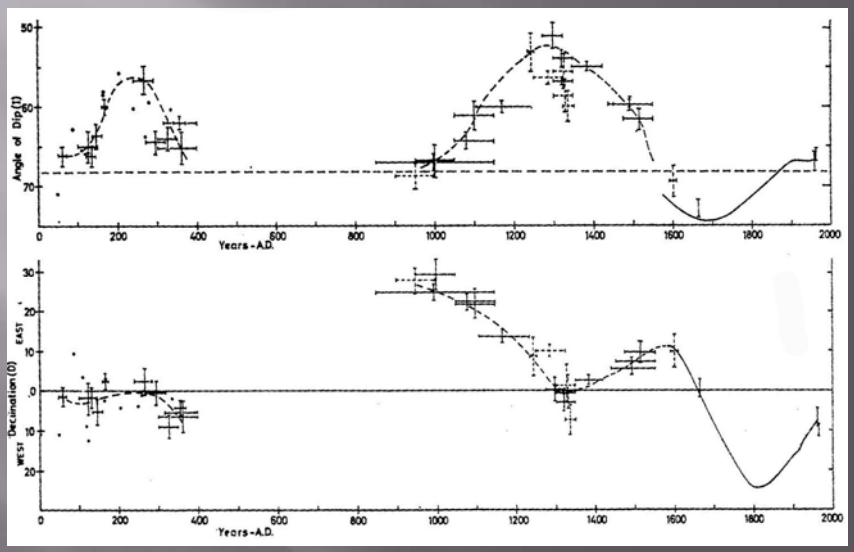
With archaeological features there are three points to consider:

The feature must be made of clay

Have been heated to over 550°C

Still be in situ – not been moved, cracked or slumped.

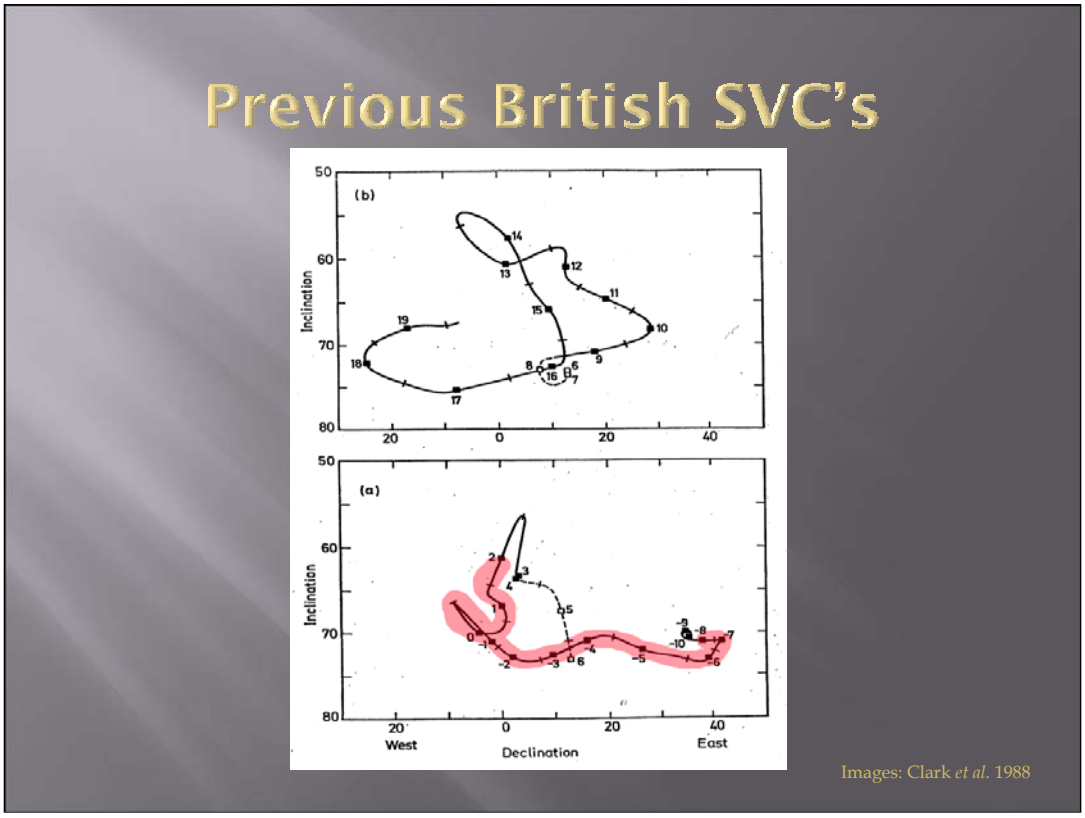
Previous British SVC's



Images: Aitken *et al* 1963

It wasn't until the 1960's that enough magnetic data from archaeological features had been acquired to attempt to use it to produce a curve detailing the secular variation beyond the extent of historical records, which only go back to the 17th century.

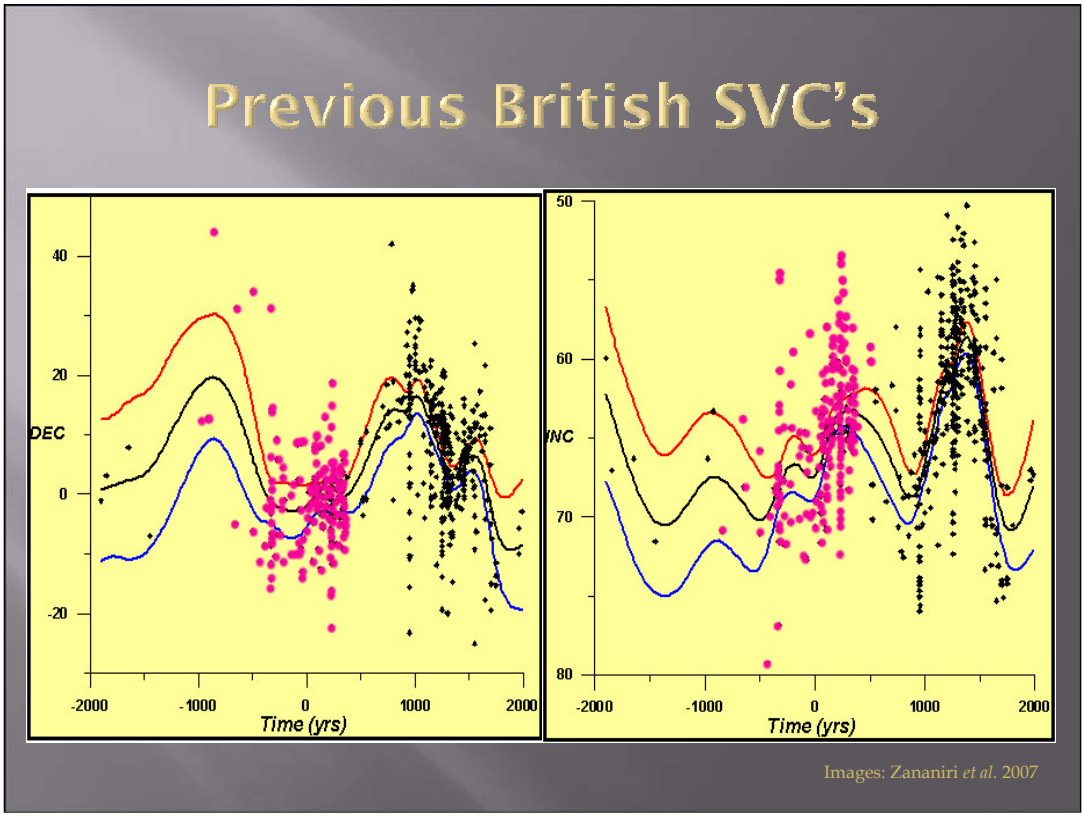
This first attempt by the Oxford laboratory only went back to 1AD and shows that there were many gaps in the record. Inclination is shown at the top and declination at the bottom both are against time.



Images: Clark *et al.* 1988

Twenty years later an updated curve was published, this incorporated lake sediment data so extended back to 1000BC. The area of the curve which contains the lake data is highlighted in red.

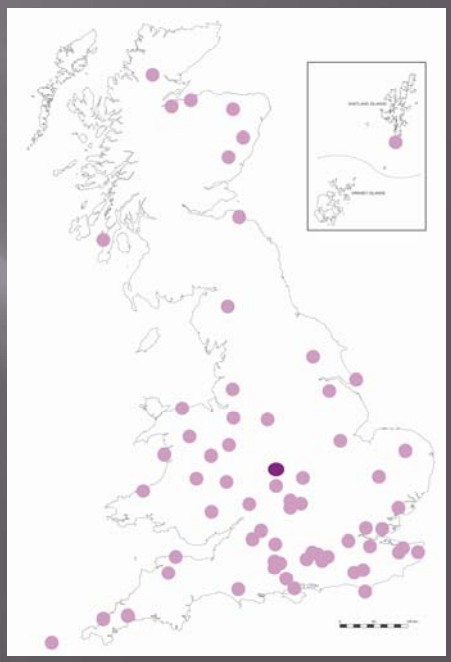
This was a controversial decision at the time and there are still unresolved debates in the literature about the validity of combining them. My feeling is that lake data are useful but must be applied critically and I will return to this point later. This curve was presented as a Bauer plot with inclination on the y axis and declination on the x axis. Time is shown along the curve. This is a misleading representation as the gaps apparent in the previous curve still exist.



The most recent curve was published two years ago and the main differences here are that the lake data have been excluded and the curve was produced using a Bayesian hierarchical approach so many of the errors have been accounted for. The data used to construct this curve have been plotted on and my focus has been on the pink points. You can see that many of the points fall outside the error ranges of the curve which suggests that these data could be refined.

Collected more data

- Original data: **59 sites** (purple) providing **114 directions**
- Visited: **7 new sites** (green) collecting **21 new directions**
- New data: **41 new sites** (yellow literature; orange other labs) providing **97 new directions**
- Now a total of **107 sites** providing **232 magnetic directions**



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I started by focusing on collating more data and reviewing the quality of the data already in the database. Originally for the first millennium BC there were 114 directions I have checked that the details are correct and made any necessary changes.

Collected more data

- Original data: **59 sites** (purple) providing **114 directions**
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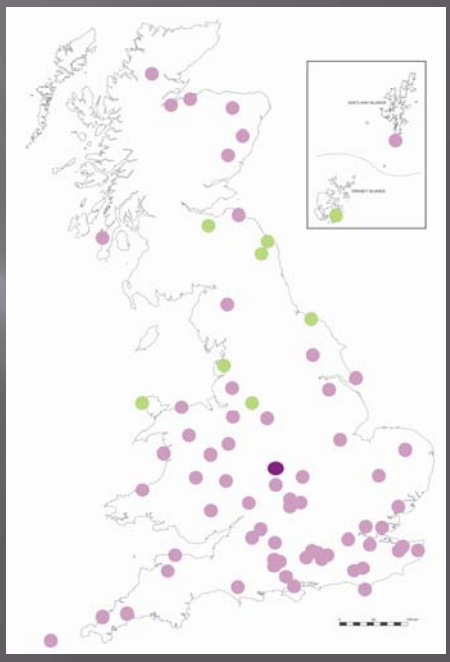

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Over the past 18 months have been advertising archaeomagnetic services for all Iron Age excavations and even with the economic downturn reducing the number of excavations undertaken I have been able to sample 21 features.

Collected more data

- Original data: **59 sites** (purple) providing **114 directions**
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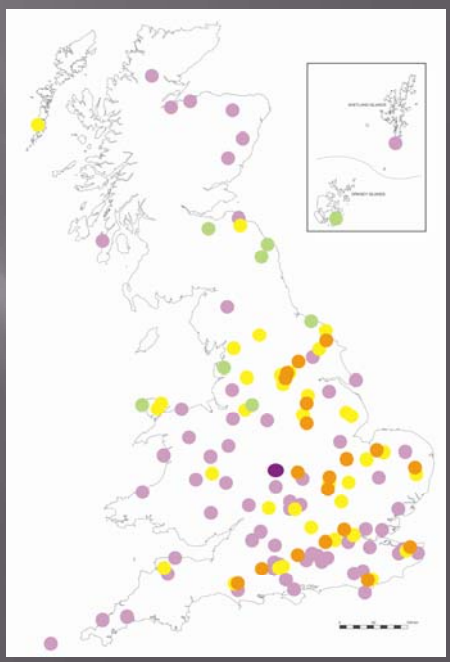

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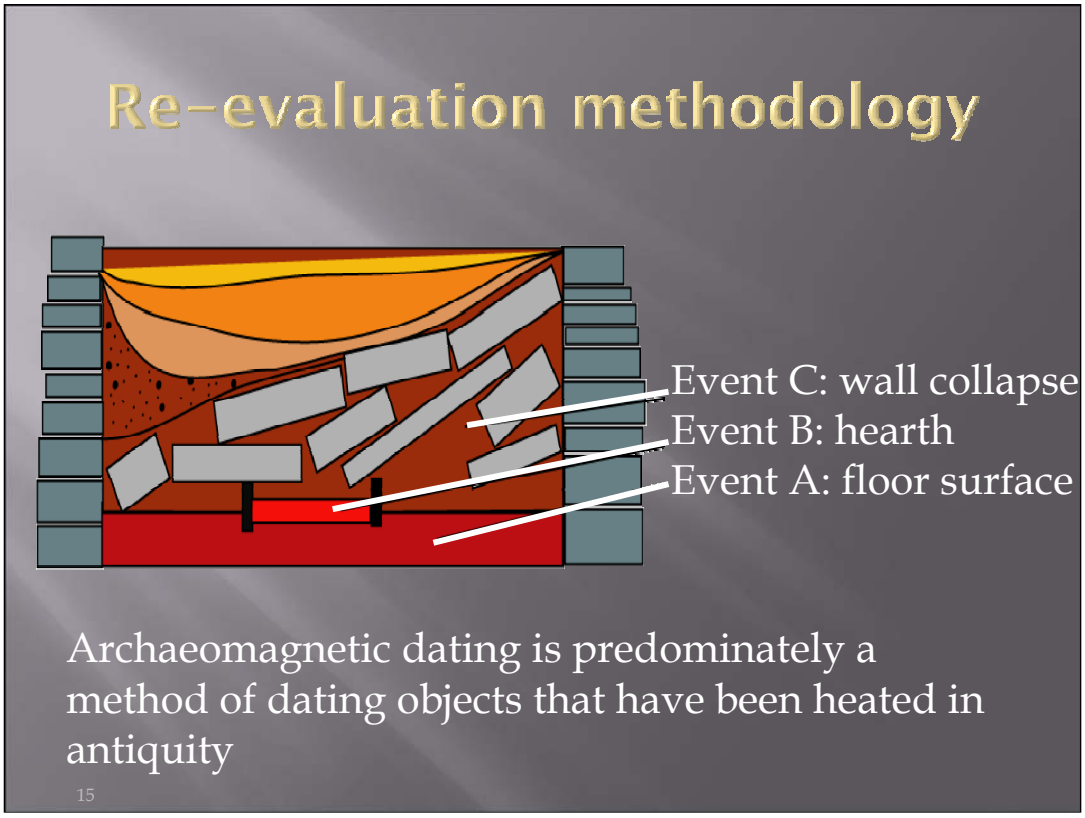
Contact with other laboratories and literature reviews have revealed another 97 features from first millennium BC sites that have been sampled for archaeomagnetism.

So I have been able to double the amount of data available for this constructing a SVC for the first millennium BC. The next question is how reliable are these data?



With regards to reviewing the data I have focused on the chronological placement assigned to each magnetic direction. In order to be used in the SVC the directions must have been dated by another means. Can think of the directions as musical notes, and I have to work out how the song goes.

I have been using the archaeology associated with each of the features sampled to provide magnetic directions to see how the event dated by archaeomagnetism fits into the site's sequence and then how the archaeological evidence can best be applied.

I have adopted a ranking system first employed by the Oxford lab to qualitatively assess the reliability of the date assigned to each magnetic direction with A being a good association and D being a very doubtful one.

Tuning the age estimates: Ferrybridge, Yorkshire

Burnt pit, radiocarbon dates from superstructure burnt during last use: 300±100 cal BC
Rank C – doubtful but worth considering

Corn dryer, dated by chronologically diagnostic artefacts from last production run:AD140±20
Rank A - confident

Images: © WYAS. Roberts *et al.* 2005 left page 108, right page 119

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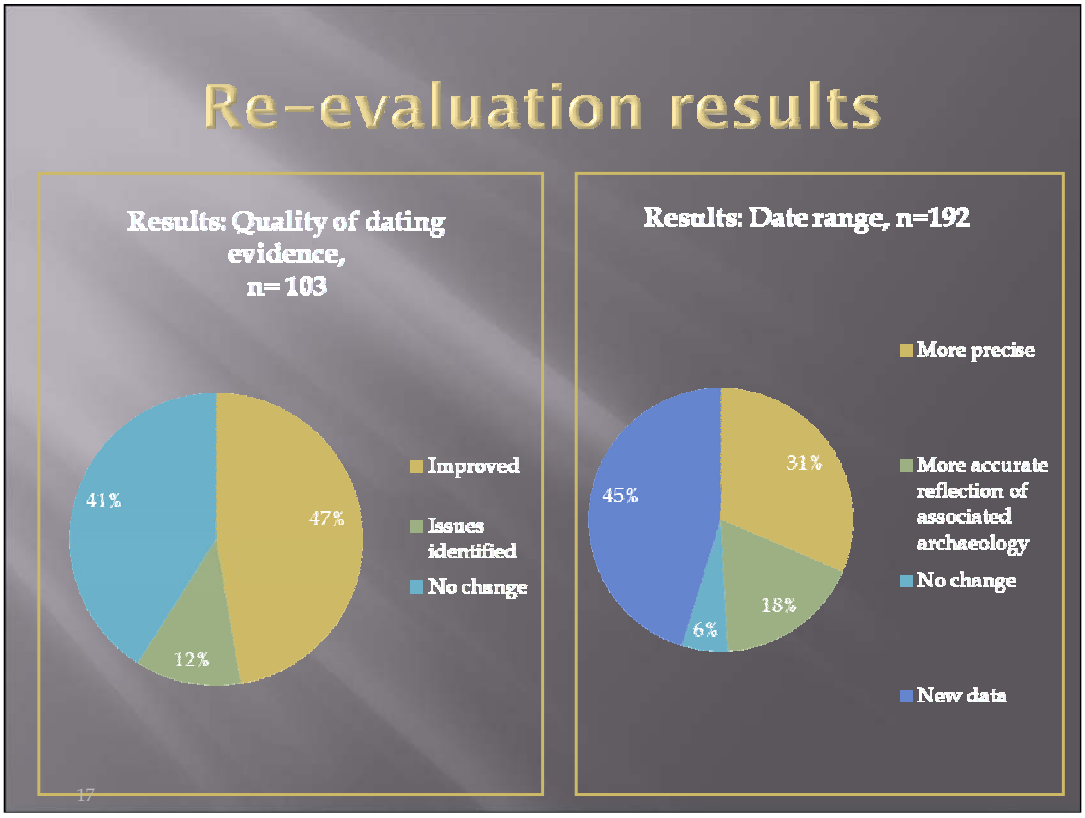
Here are two features that have been sampled for AM dating by GeoQuest Associates, a burnt pit and corn dryer both from Ferrybridge to show the process. Here as with most extensive excavations associated with commercial work, vertical stratigraphy is lacking so for this isolated burnt pit the only dating evidence is a radiocarbon date from the burnt super structure. This has been ranked C as the association between the felling of the wood and the burning in the pit is doubtful but the data are worth considering.

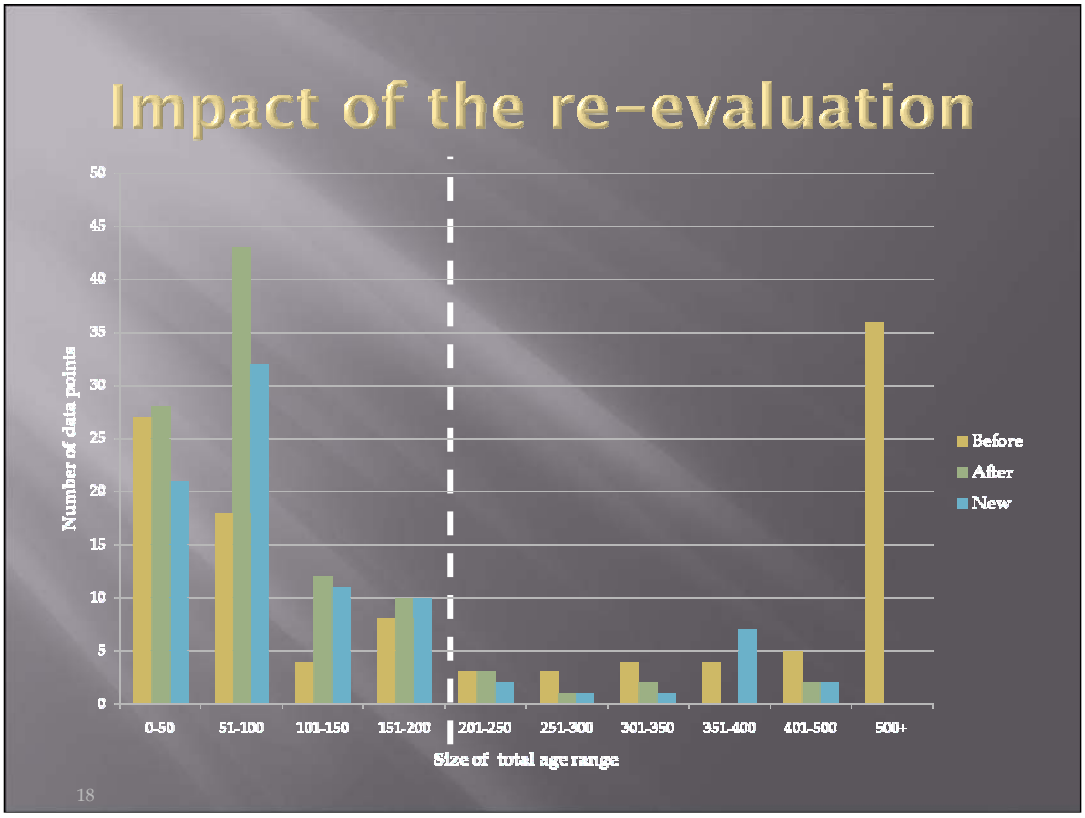
The second feature was full of ceramics and grain associated with the last use of this dryer, collectively they provide a date of AD140 which has been ranked A as the association between the events dated and the last use of the dryer is very good.



This ABC ranking system was applied to all the original data and then again to the results of the re-evaluation and this graph shows the impact of the re-assessment on the original data set. So far this re-evaluation is 92% complete therefore these results are preliminary.

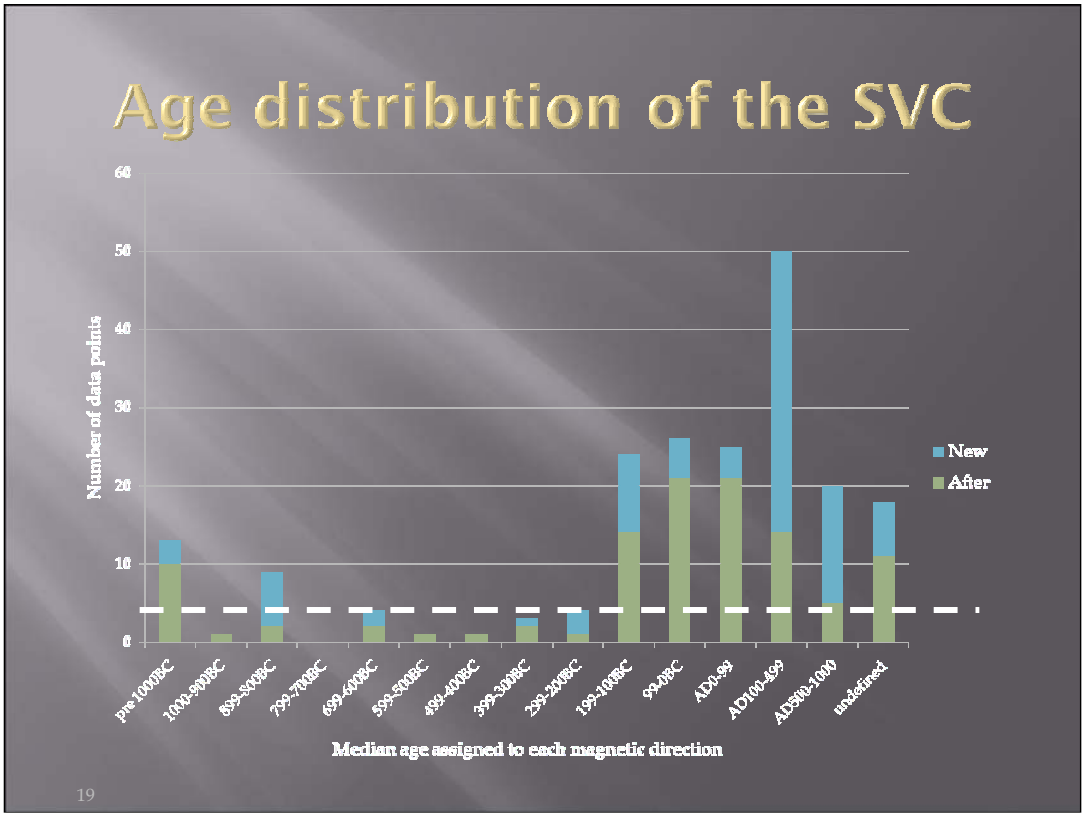
The left hand graph shows the effect on the reliability of the associated date for the original data with an improvement for nearly half of the data. For 12% of the data some issues were identified with the original date range which now more accurately reflect the associated archaeology.

The right hand graph show the effect on the precision of all the data re-evaluated so far. Just by critical application of the associated archaeological information it has been possible to make a significant improvement. Those which now have larger age ranges are generally the directions from hill forts excavated in the 1960's when they were given short spans of use during the perceived Belgic and Roman invasions. This is now an outmoded interpretation for this class of monument.



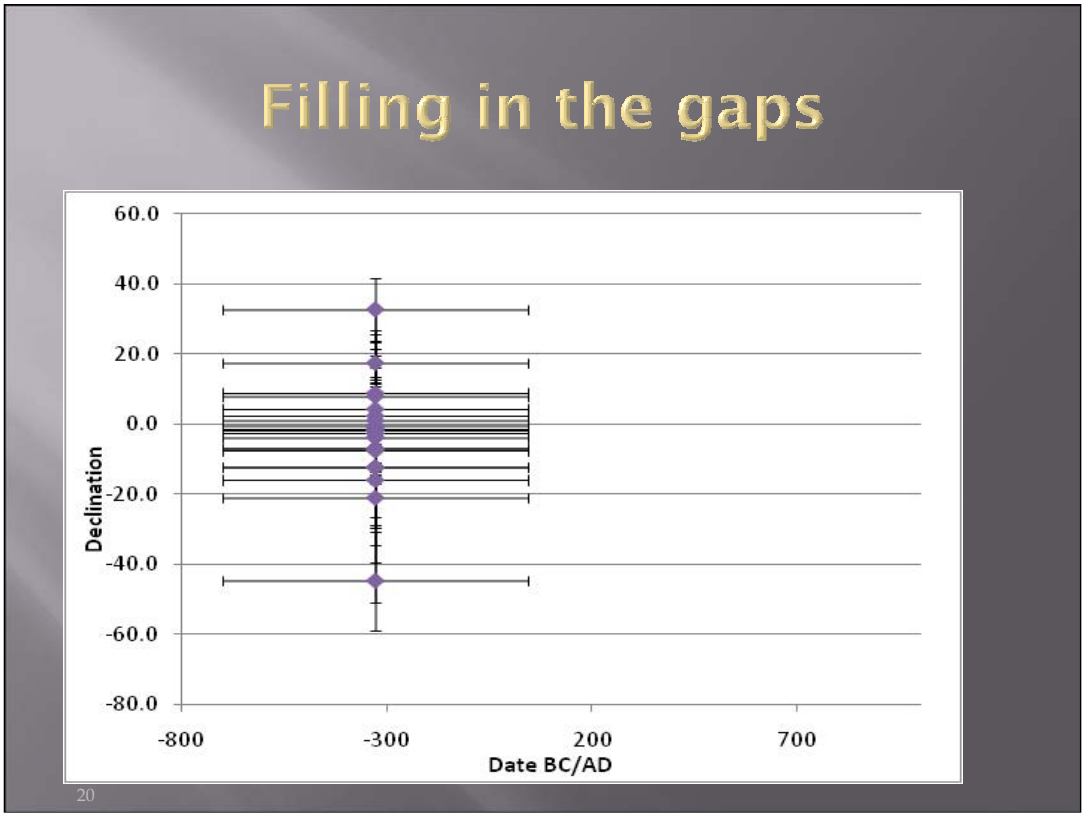
So with regards to constructing an calibration curve, it is generally consider necessary to have associated age ranges of plus or minus 100 years or less, so a total age range of under 200 years.

Before many of the data points were just allocated “Iron Age” so had large error ranges, as this graph shows more of the data now falls to the left of the cut off line.

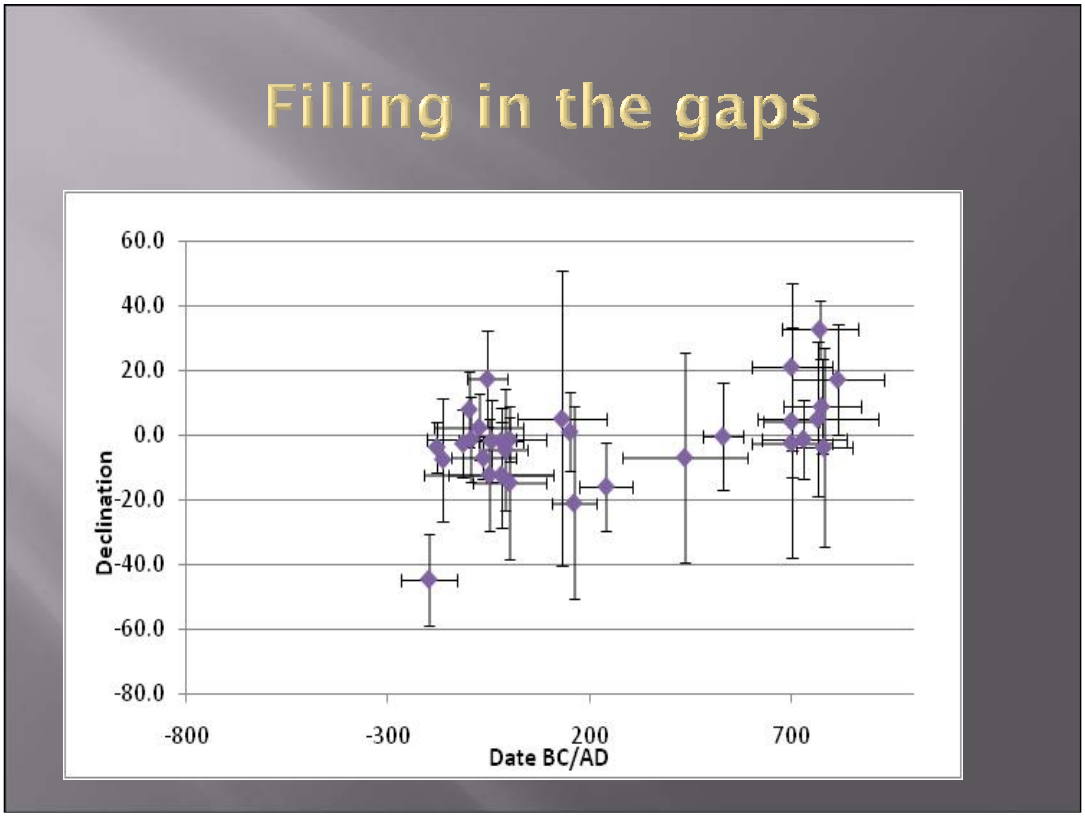


Also in order for the curve to be reliable it is preferable to have at least 5 points per century. After the review can see that a much wider span of time is covered, this is due to the regional differences in Iron Age archaeology.

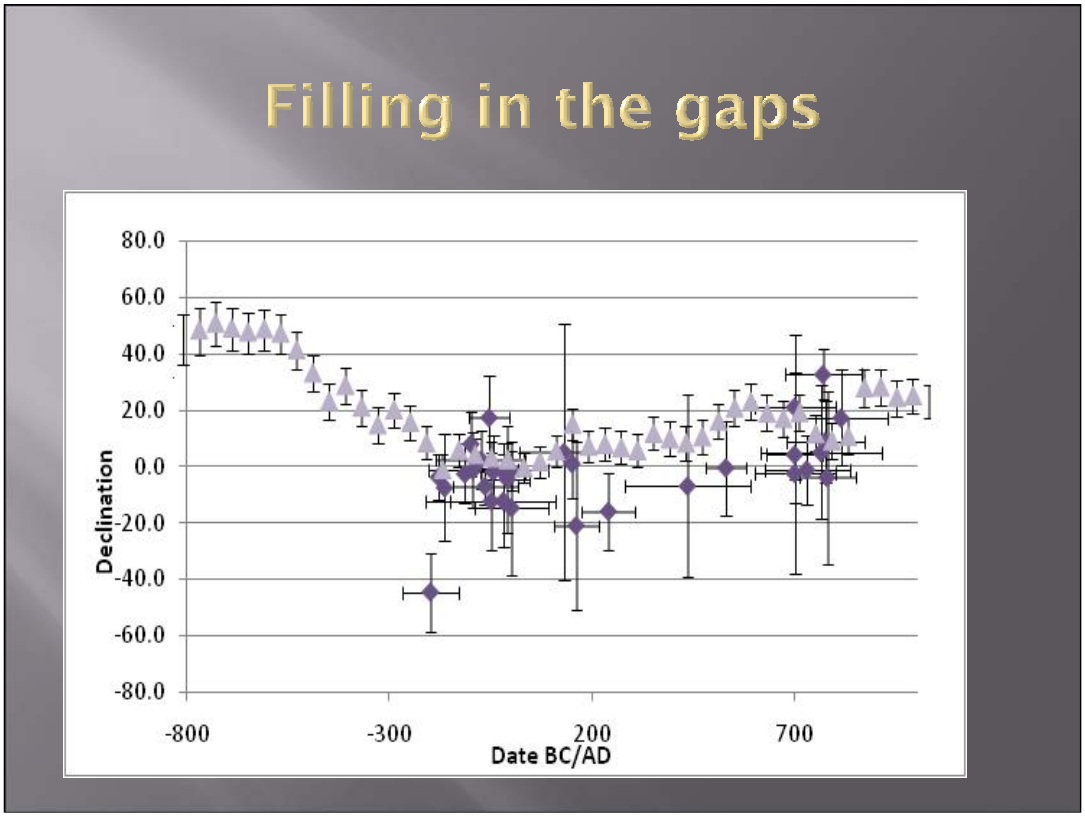
There are still gaps, but these now reflect the nature of the archaeological record. Early Iron age sites are particularly difficult to identify and many middle Iron Age sites show prolonged continuity of use. This is a problem for archaeomagnetic dating which dates the last time something was heated. Therefore I need to find another way to fill in the gaps and this is were lake sediment data may be helpful.



For purposes of clarity only a fifth of the data set are show here. This graph shows the declination component against time with their original date ranges. Can see that they are very wide and span 700BC-AD43.

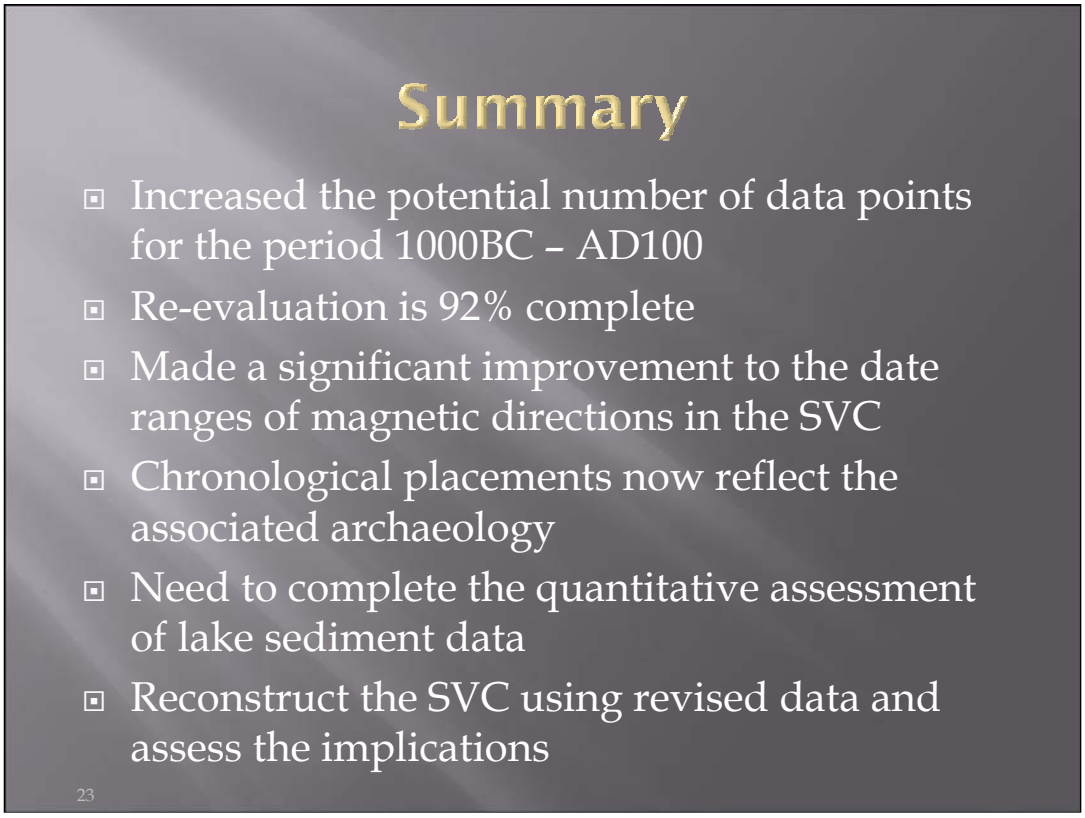


This is the same data set but with their revised age ranges. Can see that the data are starting to form a pattern.



If the magnetic directions from British lake sediments are superimposed can see that the two datasets show the same general pattern. This shows the potential of lake sediment data for use in SVC's but this research is still incomplete.

The main issue is that archaeological material and lake sediments record the ambient geomagnetic field via completely different mechanisms so the two datasets are not directly comparable.



To summarise, after two years I have been able to

Double the number of available data points

Made a significant improvement to the associated date ranges, which now reflect the associated archaeology

There is still a lot to be done, I need to complete the work with the lake sediment data and finally reconstruct the SVC and assess the implications of the refinements.

To continue the musical analogy, I hope to have a better idea of how the song goes.

To conclude, I believe it is possible to date the British Iron Age, particularly once the revised archaeomagnetic calibration curve is available.

Thank you

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http://www.brad.ac.uk/archenvi/research/postgraduate/Clelland/phd.php

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